An Analysis of several Varieties of British and Foreign Salt (Muriate of Soda), with a view to explain their Fitness for different economical Purposes. *By* William Henry, *M.D. F.R.S., Vice-Pres. of the Literary and Philosophical Society, and Physician to the Infirmary, at Manchester.* Read January 25, 1810. [*Phil. Trans.* 1810, *p.* 89.]

An opinion having for some time prevailed, both in this and in other countries, to the prejudice of British salt as a preserver of animal food, and large sums of money being annually paid to foreign nations, in conformity to this opinion, for the supply of an article which Great Britain possesses beyond almost any other country in Europe, Dr. Henry has been induced to undertake the present inquiry, for the purpose of ascertaining whether the preference of foreign salt be founded on accurate experiments, or merely a matter of prejudice; and in the former case, whether any chemical difference could be discovered that would explain that superiority.

The subject is divided into three parts: in the first of which are contained, general observations on the different kinds of salt manufactured, and the modes of preparing them. The second division contains the general statement of the results of the experiments, and conclusions deducible from them. But since a long detail of analytical processes must be uninteresting to very many persons, to whom the results will be acceptable, the description of the method employed by Dr. Henry, in his analysis, is reserved for the last section, in which (as the author observes) are not to be expected any novelties in science, but merely a careful selection and employment of known processes.

The principal sources of the salt manufactured in this country are: the rock salt of Cheshire; the brine springs, which are also mostly in the same district; and sea water, which cannot be evaporated artificially with profit, excepting where fuel is cheap.

Concerning the preparation of salt in Cheshire, Dr. Henry extracts a brief statement from an excellent history given by Mr. Henry Holland, in the agricultural report of the county of Chester; and he notices four varieties.

First. That which is called *stoved* or *lump* salt. Second. Called *common* salt. Third. Large-grained flaky salt. Fourth. Fishery salt;—the difference among these depending principally on the degree of heat used for evaporation of the brine.

The stoved salt is prepared by rapid evaporation at a boiling heat of 226° Fahrenheit, and it obtains its name from being subsequently dried in stoves after being well drained.

For making common salt, the brine is evaporated at a temperature between 160° and 170°; and as the salt is consequently formed in somewhat larger grains, it is merely drained, and does not require to be dried in stoves as the former. The name of the third, or large-grained flaky salt, implies a slower process of crystallization, and it is conducted at a temperature of 130 or 140 degrees.

The last, or fishery salt, which is the largest, is prepared at a heat

of 100 or 110 degrees. This process is so slow as to last seven or eight days, instead of eight or ten hours, which is the shortest time employed in the first mode of evaporating the same quantity of brine, and accordingly the salt forms in large cubical crystals, proper to the muriate of soda.

Of these varieties, the stoved salt is that which is usually employed for domestic purposes. The common salt is consumed principally in the salting of provisions that are not intended for sea-voyages. But for this last purpose, the large-grained or fishery salt is peculiarly fitted.

With respect to the preparation of salt from sea-water, the author takes notice of the process employed on the coasts of Scotland, both east and west, where, from the cheapness of fuel, artificial heat alone is used; and of the salt-works at Lymington in Hampshire, where advantage is taken of a milder climate for removing five sixths of the water by spontaneous evaporation, previous to its admission into the boilers.

Since the evaporation in each of these works is conducted rapidly during the formation of the salt, it generally resembles the stoved salt of Cheshire; but in consequence of the heat being slackened during Sundays, a larger kind is then formed, and it is termed Sunday salt. At Lymington, there are also formed, by drippings from the salt during its drainage, large stalactical masses, termed salt-cats, weighing sixty or eighty pounds each; but these do not exceed $\frac{1}{100}$th part of the salt prepared at Lymington.

Of the several salts above described, the large-grained fishery salt is that which most resembles the foreign bay-salt in appearance; and in fact (says the author,) a large proportion of what is sold in London as bay-salt, and esteemed as of foreign manufacture, is this Cheshire salt.

Dr. Henry next gives a table of the results of his chemical experiments on eleven varieties of salt; and in this it appears, that the *Lymington cat* is that which contains the smallest quantity of impurity, and the Lymington or Scotch common salt the largest quantity; the first amounting to only 12 parts in 1000, and that of the last to 64.

But it appears that all the kinds of Cheshire salt are nearly equal to the *Lymington cat* in purity, and perhaps superior in respect to the *quality* of the extraneous matter, which varies in different kinds from $13\frac{1}{2}$ to $17\frac{1}{2}$ in the thousand. The foreign bay-salts, on the contrary, have as much as from 35 to 40 parts of impurity. Of these about 10 parts are insoluble, and consist chiefly of argillaceous earth, coloured by oxide of iron. The native rock salt of Cheshire also contains as much or more of insoluble impurity, which is chiefly a marly earth, with some sulphate of lime. The earthy muriates of lime and magnesia abound most in salt which is prepared by rapid evaporation of sea water.

Since common salt contains extremely little water of crystalliza-

tion, it is pretty evident that the earthy muriates discovered in the analysis of sea salt are derived from the portion of the mother water which adheres to the salt after being drained; and accordingly, those salts prepared from sea water that are smallest grained, and consequently have the largest proportion of interstice, are debased by the largest proportional quantity of this species of impurity. But of this impurity the Cheshire salts are nearly free, as they do not contain one part in 1000 of earthy muriates; and indeed it is scarcely possible that any portion of Cheshire prepared salt can contain more, since the rock itself does not contain more than 5 in 1000; while on the contrary, in sea water, the earthy muriates amount to no less than $\frac{2}{100}$ths of the entire quantity of salt contained. Dr. Henry pays particular attention to these muriates, because the propensity of common salt to deliquesce by attracting moisture from the atmosphere, depends in great measure (though not entirely) on the presence of these deliquescent compounds.

Since in the analysis of salts nominally the same, great difference often occurred even in examination by the same process, Dr. Henry endeavoured to trace the origin of this disagreement of his results. And, as he conceived it might arise from the different degrees of purity of the liquor in different stages of its evaporation, he procured three samples of common salt, of which one was taken from the boiler two hours after the first application of heat; the second at the end of four hours; and the third at the end of six hours: and he found

The first to contain 16 parts of sulphate of lime in 1000;

The second to contain 11; and,

The third only $3\frac{1}{2}$.

But on the contrary, when the impurities are of a different species, and are highly soluble, these will be found to abound most in the salt last drawn, on account of the large proportion they then bear to the aggregate contents of the mother liquor.

The author also ascertained the quantities of water contained in the several varieties of salt; but this he found to be very small, and not constant in any one, appearing rather as an accidental than a necessary ingredient in any of them.

Since the differences of chemical composition discoverable by experiment are not sufficient to account for those properties which are imputed to the several varieties of muriate of soda, the author is of opinion they must depend upon some mechanical property; and the most obvious are the magnitude of the crystals, and their degree of compactness or hardness, which must each retard the process of solution; since a given weight of the salt will expose less surface for solution, even from mere magnitude of its particles; and hence will remain more permanently between the different layers of provisions, and furnish a constant supply of saturated brine during the gradual exudation of the fluids originally contained.

For the purpose of estimating the compactness of several different varieties of salt, Dr. Henry took some pains to measure their specific

gravities, by putting equal weights successively into the same vessel, and again weighing it after filling the interstices with a saturated solution of salt.

The specific gravity of rock salt was found, thus, to be..	2125
That of the same broken into small fragments	2112
That of stoved salt was also.....	2112
Common salt	2084
Fishery salt	1909
St. Ubes, as a specimen of bay-salt	1932

The difference between the large-grained fishery salt and the bay-salt of foreign manufacture is so inconsiderable, that although the superiority of the former in chemical purity may not be considered as of any advantage for economical purposes, yet in its mechanical qualities it cannot be said to be inferior in a degree that can be prejudicial.

The methods of analysis employed by the author in this inquiry are next described. The salt to be examined was first dried at a given temperature of 180°. The earthy muriates were then separated by alcohol, and their aggregate weight ascertained after evaporation of the alcohol. An aliquot part was next dissolved, and the lime precipitated first by carbonate of ammonia, after which the magnesia was separated by phosphate of soda, as a triple ammoniacal phosphate of magnesia. A previous trial having shown that 100 grains of dry muriate of magnesia would give 151 of the triple phosphate, the quantity of muriate of magnesia was inferred from this latter precipitate, and the difference between that and the aggregate weight of the two muriates was considered as muriate of lime. Sometimes the estimation was formed in a different way, by superoxalate of potash, which was found to occasion a precipitate of 116 grains from 100 dry muriate of lime; and thence, as before, the weights of each might be inferred.

For estimating the earthy sulphates, the quantity of original salt that remained after affusion of alcohol was dissolved by long boiling in water; the earths were precipitated as carbonates by carbonate of soda. The sulphuric acid was separated by muriate of barytes, and thence estimated. The earths were then re-dissolved in sulphuric acid, dried, and their weight ascertained. Of these sulphates, the more soluble part was dissolved in a small quantity of warm water, and the magnesia precipitated, as in the former case, as a triple phosphate of magnesia.

It was found that 100 grains of this precipitate indicate 111 of crystallized sulphate of magnesia; and hence the respective quantities of the two sulphates was known: but since it was possible that some proportion of alkaline sulphates might be also present, some collateral experiments were necessary for the purpose of ascertaining whether the sulphuric acid obtained above by muriate of barytes, corresponded with that which would be contained in the mere quantities of sulphate of magnesia and sulphate of lime discovered

to be present. The quantity of sulphate of barytes produced from 100 grains of sulphate of lime was accordingly ascertained, and found to be 175·9; and 100 grains of crystallized sulphate of magnesia were found to give 112 of sulphate of barytes. And since the aggregate quantity of sulphuric acid obtained from any quantity of salt examined was found to agree with the above proportions, it was inferred that no alkaline sulphate was present in any of the varieties of muriate of soda, whether of English or foreign manufacture.

In addition to the author's account of the methods pursued in his analyses, he also mentions various objects of inquiry respecting the preparation of salt, which may be interesting to chemical readers:—such as the specific gravity of the original brine of Cheshire, and its original contents; the specific gravity of mother liquors, and their ultimate contents; the clearings of brine, which are raked out as soon as the salt begins to granulate; the pan-scale, that forms as a hard crust, attached to the pan in which the brine is evaporated; and the varieties in this scale, under different circumstances.

The difference between sea-water and the brine from salt-springs is also stated, and the extreme difference also of the residua obtained from the respective mother liquors, especially in respect to muriate of magnesia; since the mother liquors of Cheshire contain only 35 parts in 1000, while that of the other amounts to 874; the mere refuse of the Cheshire processes being nearly equal in purity to some kinds of salt prepared from sea-water.

Description of an extraordinary Human Fœtus. In a Letter from Mr. Benjamin Gibson, *Surgeon, to* H. Leigh Thomas, *Esq. F.R.S.* Read February 8, 1810. [*Phil. Trans.* 1810, *p.* 123.]

Although instances of human bodies nearly entire, united side by side, or back to back, or otherwise, are by no means rare in the collections of anatomists; and although such a conjunction is generally not connected with any peculiarity in the organs which compose them, and lead the physiologist to anticipate nothing curious in their internal configuration;—yet, where some parts are found double, and others single, the resources of nature become apparent in adjusting parts which have naturally no connexion. Such is the instance here described; and it appears peculiarly interesting, from the consideration, that the system of deviation was apparently compatible with life; for if the difficulty of the birth had not proved almost immediately fatal, the complexity of the structure would probably have formed no impediment to its existence.

This curious production had two heads, placed side by side, united to one body, with two legs and two arms. The countenance of the one appeared to the author to be male, and of the other female; and the conformation of the organs of generation, which partook of both sexes, confirmed that persuasion.

The trunk, though appearing as one body, was broader than natu-